Spatial-frequency EEG characteristics of suicidal ideation and suicide attempt in depressed females

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Authors:

Lars Benschop[1], Chris Baeken[1], Marie-Anne Vanderhasselt[1], Frederik Van de Steen[1], Kees Van Heeringen[1], Martijn Arns[2]

Institutions:

[1]Ghent University, Ghent, Belgium, [2]Utrecht University, Nijmegen, Netherlands

Introduction:

Current suicide risk assessments have inadequate short-term predictive power (1). Therefore, suicide risk assessment based on neuroimaging methods such as EEG may improve prevention efforts. EEG is a relatively cost-effective, accessible and time-efficient brain-imaging tool, which has been applied for both diagnostics and treatment of neuropsychiatric disorders. Nevertheless, research investigating the potential of EEG for suicide risk assessment is surprisingly scarce. The current study contrasted broadband (2 Hz – 100 Hz) resting state EEG in patients with major depressive disorder (MDD), including suicide attempters, suicide ideators and MDD patients with a low suicide risk. The aim of this data driven EEG study was to investigate whether MDD patients with either a recent suicide attempt or suicidal ideation have unique spatial-frequency power characteristics when compared to MDD patients without suicidal ideation or a history of suicide attempts.

Methods:

Suicide risk was assessed using the Mini-International Neuropsychiatric Interview. We defined three distinct groups based upon suicide risk: a) MDD's who attempted suicide within the previous 30 days (N = 19) b) MDD's with only suicidal ideation (SI) (N = 36) and c) MDD's without a history of SI and suicide attempts (N = 23). The EEG eyes closed resting state was recorded for 2 minutes by means of a 26-channel 10-20 system Quikcap. The primary EEG analysis was performed in MATLAB. Current source density (CSD) was applied to all of the data using the spherical spline approach. Frequency decomposition was achieved through complex Morlet wavelet convolution. The wavelets' frequency spectrum was logarithmically distributed in 40 increments ranging from 2 Hz – 100 Hz. The number of wavelet cycles was adjusted as a function of frequency (i.e. 3 cycles for the lowest frequency and 10 cycles for the highest frequency). Cluster-based permutation tests were applied for statistical evaluation to control for the family wise error rate (2, 3). Since the current study used resting state data and focused on localizing power differences on topographical maps, the data was collapsed over the time dimension. Therefore, the cluster-based thresholding was applied on the spatial- (i.e. electrode grid) frequency dimension

using EEGlab's topoplot function. This resulted in a cylinder of data, comprising of 40 stacked slices (i.e. the number of frequency bins), in which each slice represents a cluster-thresholded and frequency-specific topographical plot. Lastly, eLORETA (4) was employed to localize frequency differences between the study groups.

Results:

The EEG spatial-frequency analysis revealed significant bilateral hypoactivation localized at the frontal electrodes within the beta- (15 Hz – 30 Hz) and low gamma (31 Hz – 60 Hz) band for both the attempter- and ideator groups when compared to the control group. Ideators also showed bilateral hyperactivation localized at the posterior electrodes within the alpha band (9 Hz – 13 Hz) and left hyperactivation localized at the occipital electrodes within the high beta- (25 Hz – 30 Hz) and low gamma band. When contrasting attempters with ideators, the analysis revealed right temporal hypoactivation within the high beta- and low gamma band. In addition, eLORETA localized attempter and ideator frontal hypoactivation within the orbitofrontal, the medial, middle, superior, and inferior frontal areas, and the anterior cingulate cortex. Attempter right temporal hypoactivation was localized within the right inferior, middle, superior temporal cortices, and the fusiform gyrus.

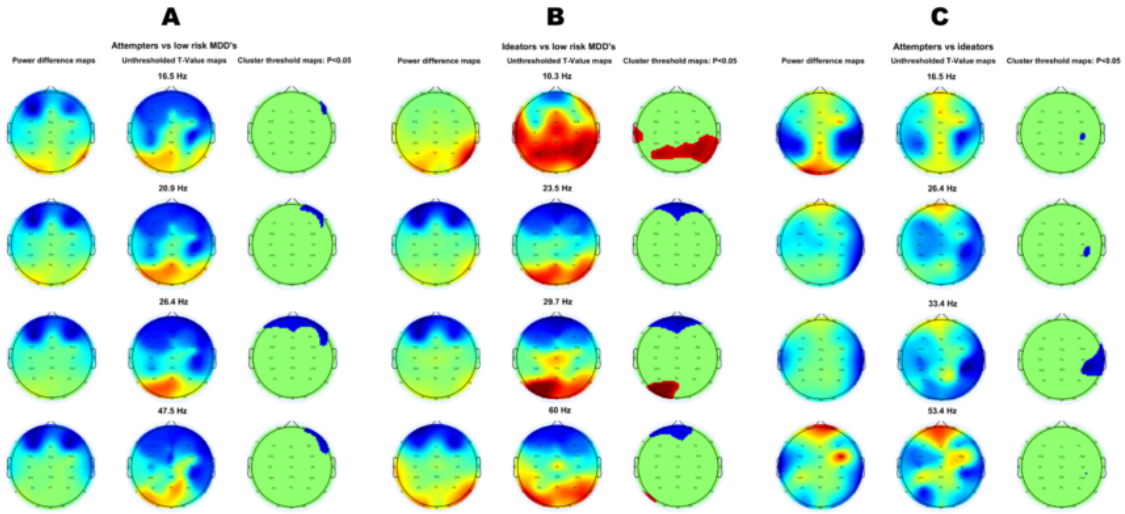

FIGURE 1: Topographical distribution of group power differences. Raw power differences, unthresholded T-values and cluster thresholded ($p < 0.05$) maps are shown for each group contrast, respectively. The four frequency bins demonstrate the power distribution for each group contrast. The first column (**A**) visualizes the hypo (blue) frontal activity (15 Hz – 53 Hz) of attempters when compared to psychiatric controls with a significant peak spatial distribution at around 26 Hz. The second column (**B**) visualizes the hyper (red) parietal activity (9 Hz – 13 Hz), hypo frontal activity (18.5 Hz – 68 Hz) and left hyper occipital activity (26 Hz – 60 Hz) of ideators when compared to psychiatric controls. The third column (**C**) visualizes the right hypo temporal activity (16.5 Hz – 53 Hz) of attempters when compared to ideators with a significant peak spatial distribution at around 33 Hz.

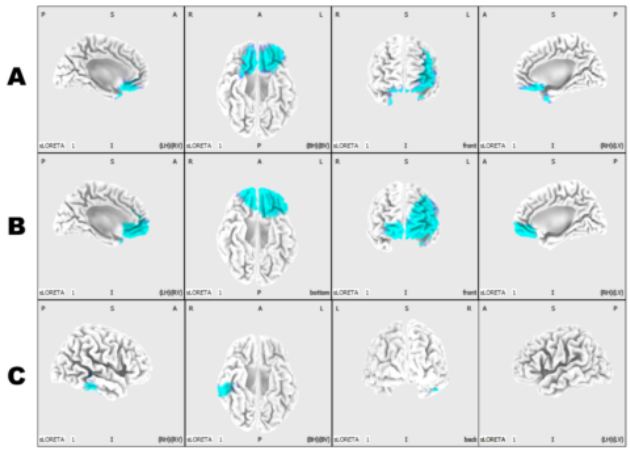

FIGURE 2: eLORETA source localization of group peak power differences. This figure illustrates significant ($p < 0.05$) localized power differences (voxels) for each group contrast for the relevant frequency bands identified in the spatial-frequency analysis. The first row (**A**) visualizes hypo (blue) frontal beta (20 Hz – 25 Hz) activity of attempters when compared to psychiatric controls, the second row (**B**) visualizes hypo frontal beta (25 Hz – 30 Hz) activity of ideators when compared to psychiatric controls and the third row (**C**) visualizes right hypo temporal gamma (31 Hz – 49 Hz) activity of attempters when compared to ideators.

Conclusions:

Frequency power characteristics of attempters and ideators are consistent with findings from the neuroimaging literature concerning suicide (i.e. the involvement of orbitofrontal areas and the right temporal gyrus in suicide attempters (5-7)), implying EEG resting state assessment could become a potential biomarker to predict suicide risk.

Disorders of the Nervous System:

Depressive Disorders [1]

Imaging Methods:

EEG [2]

Modeling and Analysis Methods:

EEG/MEG Modeling and Analysis

Keywords:

Affective Disorders
Electroencephaolography (EEG)
Psychiatric
Psychiatric Disorders
Source Localization
Other - Suicide

[1|2]Indicates the priority used for review

My abstract is being submitted as a Software Demonstration.

No

Please indicate below if your study was a "resting state" or "task-activation" study.

Resting state

Healthy subjects only or patients (note that patient studies may also involve healthy subjects):

Patients

Was any human subjects research approved by the relevant Institutional Review Board or ethics panel? NOTE: Any human subjects studies without IRB approval will be automatically rejected.

Yes

Was any animal research approved by the relevant IACUC or other animal research panel? NOTE: Any animal studies without IACUC approval will be automatically rejected.

Not applicable

Please indicate which methods were used in your research:

EEG/ERP

Which processing packages did you use for your study?

Other, Please list - MATLAB, eeglab, eLORETA

Provide references using author date format

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